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TREBALL FINAL DE GRAU

The influence of near point of convergence training on the accommodative facility

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ÓPTICA I OPTOMETRIA

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El Sr. Jaume Pujol i Ramo, i la Sra. Clara Mestre i Ferrer com a director i tutora del treball,

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Que la Sra. Maria Figuls Riu ha realitzat sota la seva supervisió el treball: The influence of near point of convergence training on the accommodative facility, que es recull en aquesta memòria per optar al títol de grau en Òptica i Optometria.

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Sra. Clara Mestre i Ferrer — Tutora del TFG

Terrassa, 12 de Juny de 2017

GRAU EN OPTICA I OPTOMETRIA

THE INFLUENCE OF NEAR POINT OF CONVERGENCE TRAINING ON THE ACCOMMODATIVE FACILITY

SUMMARY

The purpose of this pilot study was to determine if training the near point of convergence using the pencil's push-up test during 3 minutes, the accommodative facility is improved for his synkinetic association. One optometrist measured the binocular accommodation facility in near vision to 10 subjects before and after training the convergence using pencil push-up. To analyze the results, the Shapiro-wilk test is done, then it has been done the Wilcoxon sign-rank test, because the distribution is skewed.

It can be deduced that the differences of the accommodative facility before and after training the near point of convergence are not statistically significant to eliminate the null hypothesis, because applying non parametric Wilcoxon sign-rank test, $p<0,5$ .There are no significant differences between the two measures. It has not been proven that training the near point of convergence can improve the accommodative facility.

There is a large list of factors that can affect the results of this pilot study. The fact more likely present is that we have only trained the near point of convergence for 3 minutes. In addition to this there exists the fatigue factor. The sample of subjects is small according to the variability of the results. The near point of convergence training results in some improvement in both objective findings and symptoms for some subjects. This article serves as a basis for further studies, surly improving the methodology of the test could surely arrive at more robust conclusions.

RESUMEN

El propósito de este estudio piloto era determinar si entrenando el punto próximo de convergencia usando el método del push-up durante 3 minutos, la flexibilidad acomodativa es mejorada por su asociación kinestésica. Un optometrista mesuró la flexibilidad acomodativa binocular de cerca a 10 sujetos antes y después de entrenar la convergencia con el método del push-up. Para analizar los resultados, fue utilizado el Shapiro-wilk test, después se hizo el test del Wilcoxon sign-rank, para conocer si la distribución era simétrica.

Finalmente es deducido que las diferencias de flexibilidad de acomodación antes y después de entrenar el punto próximo de convergencia no tienen suficiencia estadística para eliminar la hipótesis nula porqué aplicando Willcoxon sign-rank test, $p<0,5$. No existen diferencias significativas entre las dos mesuras. No está corroborado que entrenando el punto próximo de convergencia la flexibilidad acomodativa mejore.

Existe una larga lista de factores que pueden afectar el resultado del estudio piloto. El factor más importante es que el punto próximo de convergencia solo es entrenado 3 minutos. También existe el factor del cansancio. La muestra de sujetos es pequeña por la variabilidad de los resultados. El entreno del punto próximo de convergencia da lugar a una cierta mejora en los resultados objetivos y síntomas para algunos sujetos. Este estudio sirve como base para futuros estudios, mejorando la metodología del test seguramente sería fácil arribar a conclusiones más robustas.

RESUM

El propòsit d'aquest estudi pilot era determinar si entrenant el punt pròxim de convergència utilitzant el mètode del push-up durant 3 minuts, la flexibilitat acomodativa millorava per la seva relació d'associació. Un optometrista va mesurar la felxibilitat acomodativa binocular d'aprop a 10 participants abans i després d'entrenar la convergència amb el mètode d'aproximació. Per analitzar els resultats es va utilitzar el test Shapiro-wilk, després es va utilitzar el test Wilcoxon sign-rank, per conèixer si la distribució de les dades era simètrica o no.

Finalment a través de les dades es dedueix que en la flexibilitat d'acomodació abans i després d'entrenar el punt pròxim de convergència no tenen suficiència estadística, per tant no es va poder eliminar la hipòtesis nul·la ja que aplicant Willcoxin sign-rank test, $p<0,5$. No existeixen diferencies significatives entre les dues mostres. No es pot corroborar que entrenant el punt pròxim de convergència la flexibilitat acomodativa millori.

Existeix una llarga llista de factors que poden haver influït en el resultat de l'estudi pilot. El factor més important és que el punt pròxim de convergència només és entrenat durant 3 minuts. També existeix el factor del cansament. La mostra de pacients és petita per la variabilitat de resultats obtinguts. L'entrenament del punt pròxim de convergència dona lloc a una certa millora en resultats objectius i símptomes d'alguns pacients. Aquest estudi serveix com a base per a futurs estudis, millorant la metodologia del test segurament es podrien arribar a unes conclusions més clares.

The influence of near point of convergence training on the accommodative facility

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Abstract.

Purpose: The purpose of this pilot study was to determine if training the near point of convergence using the pencil's push-up test during 3 minutes, the accommodative facility is improved for his synkinetic association.

Method: One optometrist measured the binocular accommodation facility in near vision to 10 subjects before and after training the convergence using pencil push-up. To analyze the results, the Shapiro-wilk test is done, then it has been done the Wilcoxon sign-rank test, because the distribution is skewed.

Results: It can be deduced that the differences of the accommodative facility before and after training the near point of convergence are not statistically significant to eliminate the null hypothesis, because applying non parametric Wilcoxon sign-rank test, $p<0,5$ .There are no significant differences between the two measures. It has not been proven that training the near point of convergence can improve the accommodative facility.

Conclusions: There is a large list of factors that can affect the results of this pilot study. The fact more likely present is that we have only trained the near point of convergence for 3 minutes. In addition to this there exists the fatigue factor. The sample of subjects is small according to the variability of the results. The near point of convergence training results in some improvement in both objective findings and symptoms for some subjects. This article serves as a basis for further studies, surly improving the methodology of the test could surely arrive at more robust conclusions.

Keywords: Visual therapy, accommodative disorders, accommodation facility, near point of convergence.

1.Introduction

Accommodation is the ability of the eye to change the refractive power of the lens in order to focus objects placed at different distances. The accommodative process includes contraction of the ciliary muscle, which relaxes the tension of the zonular fibers and allows the elastic lens capsule to increase its curvature. Then, the power of the lens increases. Along with these changes, the thickness of the lens increases, and his equatorial diameter decreases (Figure 1). In addition, the accommodative act is normally accompanied by a change in convergence (accommodative convergence), and pupillary constriction or miosis during near fixation (Rowe, F. 2004). This is due to the fact that the ciliary muscle, the medial recti muscle of the eye and iris sphincter muscle are synkinetic associate. These muscles are controlled by parasympathetic fibers t from the Edinger-Westphal nucleus that travel along the oculomotor nerve (Bhoala, R. 2006).

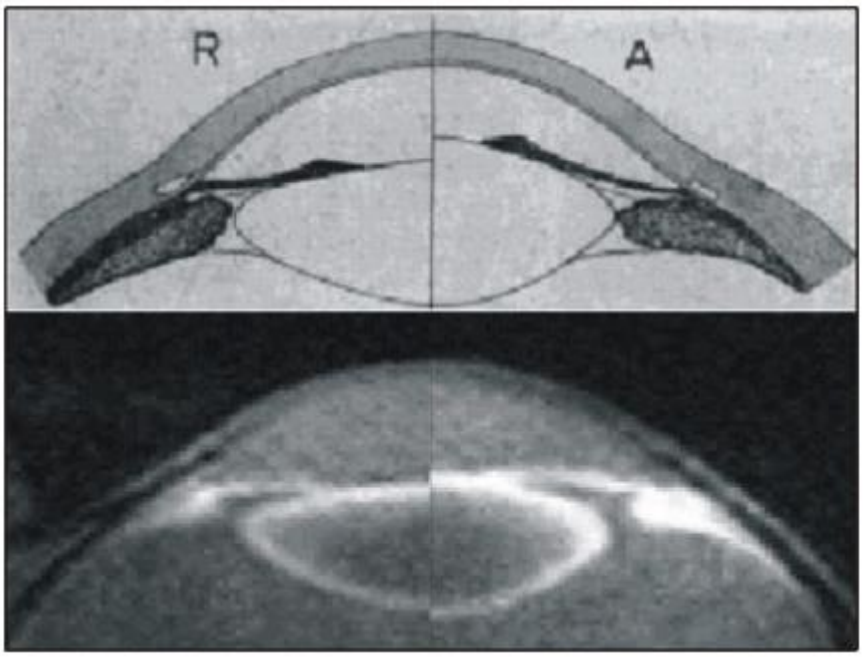

Figure 1: Accomodative system. (Strenk, S.A. 2005)

The furthest distance at which an object can be seen clearly is called the remote point. In order to see this object, the accommodative system is in its resting state, the ciliary muscle is relaxed, and the refractive power of the lens is at the minimum. The nearest point the eye can see clearly is called the near point, and then, maximum accommodation is required. At this moment the lens has its maximum power. The difference between the refractive power of the eye in these two conditions (at rest with minimal refraction, and fully accommodated with

maximal refraction) receives the name of amplitude accommodation. These amplitude declines with the age (approximately 0.3D per year). When the near point of the eye is more remote than the reading distance, the patient has presbyopia. Once presbyopia occurs, people need an optical aid (a positive lens) for near vision. (Sterner, B. 2004).

There are different metrics to analyze the accommodative system: amplitude of accommodation, accommodation facility, relative amplitude of accommodation and accommodative lag. The one which will be used in this study is the facility of accommodation.

The accommodative facility test evaluates the dynamics of the accommodative response. At near vision +/- 2.00 D lens are used and at distant vision neutral and -2.00 D lens flippers are used. Children and young adults should be able to alternate focusing by using a monocular flipper during 12 cycles per minute and there should not be more than two cycles of difference between the eyes. The normal value of binocular accommodative facility is 9 cycles per minute (Martín, R., Vecilla, G. 2010).

Amplitude of accommodation can be measured in two different methods. The Donders method consists in moving closer a target of 20/30 visual acuity on the accommodative rule, toward one eye, along the median plane of the eye, until the subject reports blur vision. Then, the amplitude of accommodation is computed as the inverse of the distance between the patient and the target (in meters). (McBrien, A., Millodot, M. 1986; Scheiman, M. 2011).

The Sheard's method consists in placing a test of AVmax-1 at 40 cm. Negative lenses are added monocularly in steps of 0.25 D until the patient reports blur vision. Then, the amplitude of accommodation is quantified as the absolute value of the added lenses plus 2.5 D (the inverse of the distance of the target). These two tests can also be measured binocularly, but then the convergence interferes (Martín, R., Vecilla, G. 2010).Donders test results are 2D lower than Sheard test. (Duane, A. 1912)

The normal amplitude of accommodation can be calculated as

$$Minimum\ amplitude = 15 - 0{,}25 \cdot age$$

$$Expected\ amplitude = 18{,}5 - 0{,}3 \cdot age$$

$$Màximum\ amplitude = 25 - 0{,}4 \cdot age$$

The accommodative lag response is a measure of the actual accommodation that occurs when an object is presented to the eye. A lag of accommodation occurs when instead of focusing right on the plane of the stimulus, one actually focuses on a further plane. If one focuses on a plane closer than the stimulus plane, it is called a lead of accommodation.

There are several accommodative dysfunctions that can be treated with visual training. The most common ones are accommodative insufficiency (Duke-Elder S. 1971). A 1-year clinical trial in 1979 determine the prevalence of general dysfunctions in binocular vision with a population subjects aged 18 to 38 years. A high prevalence of binocular vision dysfunctions was found. Of the subjects, 61.4% had accommodation disorders. Accommodation insufficiency was most prevalent among those with symptoms (11.4%) and majority has the facility of accommodation lower than the other people. (Montés-Micó, R.2001).

Accommodative insufficiency occurs when the amplitude of accommodation is lower than the expected value for the corresponding age. Patients with accommodative insufficiency usually demonstrate poor accommodative sustaining ability, they usually fail the +/− 2.00 D flipper test and have positive relative accommodation under −1.50 D. Patients often complain about blurred vision after sustained reading or at the end of the day, difficult reading, irritability, poor concentration, and/or headaches. To treat the accommodative insufficiency the general health problem and any associated binocular anomaly should be treated first. Then, it might be necessary to do visual training lenses exercises, use bifocal lenses or contact lenses. (Copper, J. 2011; Stidwill, D. 1998)

In order to accurately perform visual daily tasks, it is necessary for the accommodative system to be dynamic, fast, and precise to ensure a well-focused image on the retina. For this reason it is important to have good amplitude and good facility of accommodation. These visual skills can be improved with vision training or therapy.

The visual therapy is a clinical approach to correct several ocular dysfunctions, such as eye movement disorders, accommodative and binocular disorders, strabismus, amblyopia, nystagmus, and certain visual perceptual (information processing) disorders. The practice of vision therapy entails a variety of non-surgical therapeutic procedures designed to modify different aspects of visual function. Its purpose is to cure or ameliorate a diagnosed neuromuscular, neurophysiological, or neurosensory visual dysfuncion. Vision therapy typically

involves a series of treatments during which carefully planned activities are carried out by the patient under professional supervision in order to relieve the visual problem (Cohen,A. 1988).

It has been shown that vision therapy procedures improve accommodative function effectively and eliminate or reduce the associated symptoms. The improved accommodative function appears to be fairly durable after treatment (Rouse, M. 1987). There is a solid base of research supporting vision therapy as an effective treatment for accommodative deficiencies (Cohen, A. 1988). For example, Wold reported the evolution of 100 children who underwent accommodative vision therapy procedures. These clinically selected cases showed an 80% rate of improvement in accommodative amplitude and 76% in accommodative facility (Wold, RM,1978; Rouse, M. 1987).

A complete visual therapy program typically requires form 12 to 24 in-office sessions with a duration of around 45 min and it must be accompanied by daily exercises at home. The total number of therapy sessions depends on the age of the patient and his or her motivation and compliance (Sheiman, M.1994).

A visual therapy program is normally divided into four phases. The difficulty of the exercises increases in each phase. Typically, the fourth phase is a maintenance level to keep the achieved abilities.

In the first phase the exercises are very simple. The first ability to be treated is the one which is more affected. For example, in an insufficiency of accommodation case, the first goal will be to normalize the amplitude of accommodation. It is also important to develop progressively voluntary convergence or divergence, develop feeling of looking close and away, stimulate relax accommodating, and normalize positive and negative fusional vergence amplitudes. In the second phase it normalizes ability to stimulate and relax accommodation, incorporate speed of response into accommodative techniques, normalize fusional vergence amplitudes progressively and jump vergence facility. In the third phase the integration of accommodative facility with binocular vision techniques is trained, as well as the ability to change from a convergence to a divergence demand, the integration of vergence with versions and saccades, the vergence amplitudes at intermediate distances and facility at far vision. In fourth phase you only need to keep this abilities in 3 or 4 more sessions. (Sheiman, M.1994).

In this work, the accommodative facility was measured before and after an intensive training of the near point of convergence during three minutes. The objective of this study is to analyze if the facility of accommodation improves after training with an exercise which involve both accommodative and vergence abilities.

2. Methodology

In this study, was measured the accommodative binocular facility in near vision before and after training the near point of convergence for 3 minutes.

10 healthy subjects were recruited from the staff and students of the Faculty of Optics and Optometry of the Universitat Politècnica de Catalunya (UPC) (Terrassa, Spain) to participate in the study. The mean age ± SD (standard deviation) was 24 ± 6years (range from 18 to 30 years). The spherical refractive error of patients ranged from -7.00 D (diopters) to +1.50 D and the astigmatism was smaller than -1.00 D in all subjects. The visual acuity was equal or greater than 20/20 with their habitual correction. Besides, no history of any ocular pathology, surgery and/or pharmacological treatment.

An optometrist first measured the binocular accommodative facility of the subject with a test of AVmax-1 at 40 cm with direct light, using the usual correction, and using a + 2.00 / -2.00 D flipper always starting with the positive lenses. The patient warns us every time that see the test sharp. The exam lasts 1 minute and at the end of the measure, the cycles per minute are recorded. Afterwards and without rest, the movement of convergence was trained, by means of the near point of convergence. The subject were asked to look at the tip of a pencil located in front of his eyes at a distance of 40 cm, this pen is progressively approach to the patient until it indicates diplopia. Then, the pencil was slowly returned at a distance of 40 cm to start again (pencil push-up prof). This procedure was repeated during 3 minutes. Then, the measure of accommodative facility was repeated and finally annotated.

This work is a pilot studio, to show if working convergence, with doing the near point of convergence, improves accommodation facility binocular in near vision. It will be measured if training near the point of convergence can improve binomial accommodative flexibility closely .After training the near point of convergence the hypothesis alternative is that if near point of convergence is trained the accommodative binocular facility in near vision will improve. The

null hypothesis is that there are no significant differences in the accommodative facility with the training of near point of convergence.

There exist the independent variable, two moments in the time, the ones without training the near point of convergence and the other with the near point of convergence trained, This variable is qualitative related nominal, and the dependent variable are the cycles per minute achieved with the prof of binocular accommodative facility in near vision, this variable is quantitative.

The statistical analysis was done using the software SPSS Statistics and the Microsoft Office Excel 2007. For analyze the results, the Shapiro-Wilk test is done, to check for normality. It the result is more than $p>0,05$ it is considered that measurements are normal distributed, and it could be done the Paired-t-test, but if $p<0,05$ the values not meet the norm, the distribution is skewed, then it has been done the Wilcoxon sign-rank test. In these case the comparison between the measurements was analyzed applying non parametric Wilcoxon sign-rank test, because in this case there was not normal distribution, the result of Shapiro-Wilk test is lower than $p<0,05$. Finally, to study the agreement between data, the Bland and Altman analysis was use.

3. Results

The results of the measures of accommodative binocular facility in near vision before (M1) and after training the near point of convergence for 3 minutes (M2) are shown in Table 1. To know if the measurements are in compliance with the normal values, the test of Shapiro-Wilk test is performed. For the first measure the value of Shapiro-Wilk test is $p=0,718$ and meets normality but the second measure the value is $p=0,042$ thus the distribution is not normal. For these reason the median and the interquartile range are calculated. Values are shown in Table 1. The median trend has a value of 6, analyzing the interquartile range gives us high values of variability.

Subjects	M1	M2
1	5	3
2	7	6
3	4	4
4	7	8
5	5	2
6	14	16
7	2	4
8	1	3
9	12	16
10	10	11
Median	6	5
IQR	7	9

Table 1: measurements at M1 (Cycles per minute before training the near point of convergence), measurements at M2 (cycles per minute after training the near point of convergence)

The measurements are analyzed applying non parametric Wilcoxon sign-rank test, because there was not normal distribution. The statistical value is Z= -0,84 and significant value is p=0,401. Differences are not statistically significant.

The coefficient of repeatability (CoR) is computed as follows:

1, 96 SD diff = CoR

The SD diff is 2, 21, then the value of repeatability is 1,563.

Finally the Bland and Altman plot is used to analyze the agreement between two different datasets. The results are shown in the graphic in Figure 2.

The parametric intervals limits of agreement are calculated with:

95%L o A = mean dif+/- 1,95SD diff

Average of the differences is 0, 7. The standard deviation off the differences with two moments is 2, 21. Finally the limits are 5, 04 and -3, 64.

There are no outliers in the data sets as it can be observed, which indicates good agreement between measurements. Moreover, it can be observed that the plots do not show any recognizable pattern and therefore the differences did not vary in any systematic manner over the range of measurements.

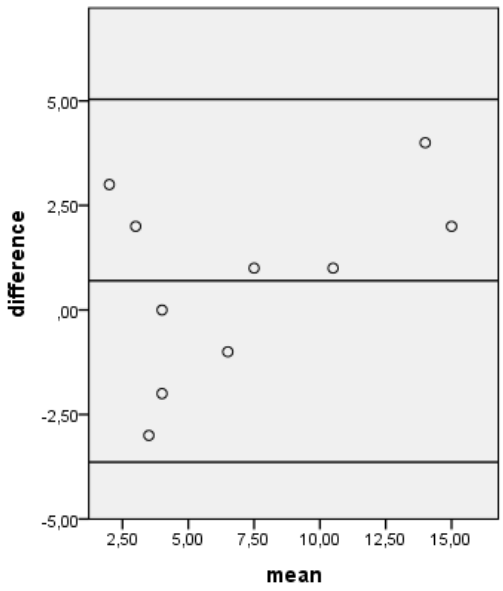

Figure 2: The Bland and Altman graphic(M1-M2).

4. Discussion

In this study, it is analyzed if training the near point of convergence for 3 minutes can improve the accommodative facility. It can be deduced from our results that the differences of the accommodative facility before and after training the near point of convergence do not differ significantly (Wilcoxon sign-rank test, p<0,5) .There are no sufficiently significant differences with two moments. It has not been proven that training the near point of convergence can improve the accommodative facility. Also, the results analyzed with Bland and Altman graphics showed agreement between two different moments and do not show any recognizable pattern that can influence the result.

There is a large list of factors that can affect the result of this pilot study. If these factors were changed the results could probably have improved. The most important fact which is more

likely present in our study is that we have only trained the near point of convergence for 3 minutes, the course of treatment may have been too short. In the next pilot study it would be important to train it for a longer time, like 10 minutes a day for 1 week. Additionally, our results might have been affected by the fatigue factor, some subjects said that they were tired at the final of the test. Surely the results could be improved by waiting 5 min before training the convergence. Finally, another factor that should be remarked is that the sample of subjects is smaller than other important studies. Our study lacks statistical power, thus we cannot provide a definite answer to our hypothesis.

The near point of convergence training result some improvement in both objective findings and symptoms for some subjects. There were some problems with limited sample size. Further study would be helpful to provide more data if treat convergence can improve accommodative system, as well as to compare the proof of near point of convergence with more comprehensive therapy protocols of accommodative problems.

The analysis is important for next pilot study. There are a large number of scientific articles comparing how the training of the near point of convergence is beneficial to improve convergence insufficiency like (Gallaway, M. 2002). or (Cooper, J. 1983) , but there are few articles to check whether near point of convergence improves accommodation. This article could not be compared with other articles, because those articles do not support the near point of convergence directly with accommodation, this article might serve as a basis for further studies.

5. Conclusions

It is argued at the beginning of the manuscript that de convergence and accommodation are synkinetic associated because the muscles that control accommodation and convergence are controlled by parasympathetic fibers form the Edinger-Westphal nucleus. The findings that are presented suggest that this association might be beneficial to work with visual therapy. For these reason, in these pilot study is compared the accommodative facility before and after training the next point of convergence during 3 minutes. As a result of the research, this study does not offer a conclusive answer to the hypothesis. This research is important to be a basis for the following studies. It would be fruitful to pursue further research about on how it can affect the training of convergence to the accommodation, and apply these results to the visual training protocol

6. Ethical and social commitment

The main objective of this work is to do a study to see the evolution of accommodation facility in near vision after training the next point of convergence. The research and knowledge in the field of health sciences has a direct impact on improving the eye health of the population and therefore in their quality of life. In this sense, there is a direct relationship between the main objective of this work and one of the four principles governing bioethics: beneficence.

Regarding the legal aspects, it must be said that it has not been considered necessary that the 10 people who participated in the study have firmed an informed consent, as all participants were from its place of practice. Finally, it would be necessary to emphasize that the security measures were appropriate to perform the study.

7. References

Bhoala, R. (2006). Binocular Vision. The University of Iowa Department of Ophthalmology & Visual Sciences. Recovered from http://webeye.ophth.uiowa.edu/eyeforum/tutorials/Bhola-BinocularVision.htm. Updated Jan. 23, 2006

Rowe, F. (2004). Clinical orthoptics. Oxford: Blackwell Pub

Sterner, B. (2004). *Ocular accommodation: Studies of amplitude, insufficiency, and facility training in young school children.* Sweden: Göteborg University

McBrien, A., Millodot, M. (1986). Amplitude of accommodation and refractive error. *Investigative Ophthalmology & Visual Science, 27* (7), 1187- 1190. Recovered from http://iovs.arvojournals.org/pdfaccess.ashx?url=/data/journals/iovs/933359/

Scheiman, M. (2011). Treatment of Accommodative Dysfunction in Children: Results from an Random Clinical Trial. *Optometry and Vision Science, 88* (11), 1343- 1352. doi 10.1097/OPX.0b013e31822f4d7c

Montés-Micó, R. (2001) *Prevalence of general dysfunctions in binocular vision*. Ann Ophthalmol 33: 205. doi:10.1007/s12009-001-0027-8

Martín, R., Vecilla, G. (2010). Manual de optometría. Madrid: Médica Panamericana

Duane, A. (1912). Normal values of the accommodation at all ages. *JAMA,* (12), 1010-1013. doi 10.1001/jama.1912.04270090254042

Duke-Elder S. (1971). Paresis of accommodation: system of ophthalmology. *Neuro-ophthalmology, 12*. Henry Kimpton: London

Stidwill, D. (1998). *Orthoptic Assessment and Management Modern optometry*. Oxford: Blackwell Science

Copper, J. (2011). Care of the Patient with Accommodative and Vergence Dysfunction. *Optometric clinical practice guideline*. Recovered from http://www.aoa.org/documents/optometrists/CPG-18.pdf

Cohen, A. (1988). The efficacy of optometric vision therapy. The 1986/1987 AOA Future of Visual Development/ Performance Task Force. *J Am Optom Assoc, 59*, 415- 420.

Rouse, M. (1987). Management of binocular anomalies: Efficacy of vision therapy in the treatment of accommodative deficiencies. *Am J Optom Physion Opt, 64*, 415- 420.

Wold, RM,(1978).Effectiveness of optometric vision therapy. J Am Optom Assoc; 49:1047-59

Strenk, SA et al. (2005) "The mechanism of presbyopia", Prog. Retin. Eye Res., 24, 379-393

Sheiman, M. (1994). Clinical management of binocular vision: heterophoric accommodative, and eye movement disorders. Philadelphia: JB Lippincott Company

Gallaway, M. (2002). The Effectiveness of Pencil Pushups Treatment for Convergence Insufficiency : A Pilot Study . *Optometry and vision science. Vol.79,No.4, 265-267*.

Cooper, J. (1983). Reduction of Asthenopia in Patients with Convergence Insufficiency after Fisional Vergence Training. *American Journal of Optometry & Physiological Optics.* Vol.60. No.12, 982-989.

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